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PATENT

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Hiromune MATSUOKA		:
Serial No.:	New - (National Phase of PCT/JP2004/007490)	:
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For:	AIR CONDITIONER	:

SUBMISSION OF TRANSLATION

Assistant Commissioner of Patents
Washington, DC 20231

Sir:

Applicants submit herewith an English translation of the International Patent Application No. PCT/JP2004/007490, which includes twenty four (24) pages of specification and three (3) sheets of drawings.

The attached document presents a true and complete English translation of International Patent Application No. PCT/JP2004/007490.

Respectfully submitted,

David L. Tarnoff
Reg. No. 32,383

SHINJYU GLOBAL IP COUNSELORS, LLP
1233 Twentieth Street, NW, Suite 700
Washington, DC 20036
(202)-293-0444
Dated: 2-8-05

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SPECIFICATION

Air Conditioner

Technical Field

The present invention relates to an air conditioner, and more particularly relates to an air conditioner comprising a plurality of utilization units.

Background Art

From the standpoint of environment preservation, the working refrigerant in air conditioners used in the air conditioning of buildings and the like is being changed over from R22 to R407C of HFC refrigerants.

Insofar as such an air conditioner used in the air conditioning of a building and the like is provided with a plurality of utilization units, the operating load fluctuates greatly, and attendant therewith the amount of refrigerant circulating in a refrigerant circuit fluctuates, thereby causing a fluctuation in the surplus refrigerant inside the refrigerant circuit. This surplus refrigerant is sometimes pooled as a liquid refrigerant in an accumulator connected on the inlet side of a compressor.

However, because R407C is a non-azeotropic refrigerant, making the surplus refrigerant pool in the accumulator unfortunately causes a compositional change in the refrigerant during the evaporation process in the refrigerating cycle process, i.e., during the refrigerant evaporation process (during cooling operation) in a utilization side heat exchanger of a utilization unit, and during the refrigerant evaporation process (during heating operation) in a heat source side heat exchanger of a heat source unit, resulting in a rich state of the low boiling point component R32 in the gas phase inside the accumulator, and a rich state of the high boiling point component R134a in the liquid phase inside the accumulator. Consequently, the R32-rich refrigerant is sucked into the compressor and circulates inside the refrigerant circuit, and there is a risk that the overall air conditioner will not achieve the performance expected of R407C.

In contrast, it is known to suppress a compositional change in the refrigerant by connecting the accumulator and a refrigerant pipe, wherein a high-pressure liquid refrigerant flows, with a bypass pipe, and also to detect the composition of the refrigerant and optimally control operation in accordance with compositional change (e.g., refer to Patent Documents 1, 2, 3, and 4). In addition, an air conditioner is also known wherein the surplus refrigerant is made to pool in a receiver connected to the refrigerant pipe, wherein a high-pressure liquid refrigerant flows, and to suppress a compositional change in the refrigerant attendant with the evaporation process (e.g., refer to Patent Document 5).

Patent Document 1

Japanese Published Patent Application No. HEI 8-35725.

Patent Document 2

Japanese Published Patent Application No. HEI 10-220880.

Patent Document 3

Japanese Published Patent Application No. HEI 10-332211.

Patent Document 4

Japanese Published Patent Application No. HEI 11-173698.

Patent Document 5

Japanese Published Patent Application No. 2001-183020.

Disclosure of the Invention

There is a problem in that, if the accumulator and the refrigerant pipe, wherein a high-pressure liquid refrigerant flows, are connected by a bypass pipe as in an air conditioner that uses the former R407C mentioned above, then the constitution as well as operation and control of the refrigerant circuit become complicated.

On one hand, if a receiver is connected to the refrigerant pipe, wherein a high-pressure liquid refrigerant flows, instead of the accumulator as in the air conditioner that uses the latter

R407C mentioned above, then it is preferable in that the constitution as well as operation and control of the refrigerant circuit are not as complicated as the former.

However, even in the field of air conditioners used in the air conditioning of buildings and the like, those that use a refrigerant having saturation pressure characteristics higher than R407C (e.g., R410A and HC refrigerants) have recently begun to be developed or commercialized in order to improve air conditioning capacity and make the equipment more compact. However, in cases where a refrigerant is used having saturation pressure characteristics higher than R407C, the maximum value of the working pressure of the refrigerant flowing inside the refrigerant circuit is higher than the case wherein R407C is used (in contrast with the standard working pressure, a high pressure of approximately 1 MPa is often used, and shall be the maximum working pressure hereinbelow); consequently, the compressive strength of the parts constituting the refrigerant circuit must be increased. In particular, because the size of the parts that constitute the refrigerant circuit in an air conditioner of a building and the like is larger than a relatively compact air conditioner like a room air conditioner, if the maximum working pressure of the refrigerant circuit portion wherein a high-pressure refrigerant flows (hereinbelow, referred to as the high pressure unit) increases, then the compressive strength of the parts that constitute the refrigerant circuit must consequently be increased, which strongly tends to increase cost. Consequently, to increase the compressive strength of the receiver in an air conditioner comprising a receiver that is one of the parts constituting the abovementioned high pressure unit, the wall thickness must be increased, which increases the cost.

It is an object of the present invention to suppress an increase in the cost of the parts that constitute the refrigerant circuit in an air conditioner comprising a plurality of utilization units, even if the maximum working pressure of the refrigerant circuit increases, by using a refrigerant having saturation pressure characteristics higher than R407C.

The air conditioner according to the first invention is an air conditioner comprising a plurality of utilization units, comprising a vapor compression type refrigerant circuit and an accumulator. The refrigerant circuit comprises a high pressure unit constituted by the connection of parts capable of flowing a high-pressure refrigerant at a maximum working pressure of 3.3 MPa or higher; and a low pressure unit constituted by the connection of parts capable of flowing only a low-pressure refrigerant at a maximum working pressure of less than 3.3 MPa. The accumulator is one of the parts constituting the low pressure unit and is capable of pooling refrigerant that circulates inside the refrigerant circuit as a liquid refrigerant. Further, the refrigerant that flows through the low pressure unit and the high pressure unit is a pseudo azeotropic refrigerant, an azeotropic refrigerant, or a single refrigerant.

If using R407C as the working refrigerant of the air conditioner, then the standard working pressure of the high pressure unit is approximately 2.0 MPa. Consequently, if R407C is used as the working refrigerant, then it is often the case in an air conditioner that the maximum working pressure of the high pressure unit is set to 3.0 - 3.3 MPa, which is a pressure approximately 1 MPa higher than the standard working pressure of 2.0 MPa. Consequently, in the air conditioner that uses R407C as the working refrigerant, it is preferable that the parts constituting the high pressure unit have a compressive strength that can withstand 3.3 MPa.

However, if using a refrigerant having saturation pressure characteristics higher than R407C, then the parts constituting the high pressure unit must have a compressive strength that can withstand a pressure of 3.3 MPa or higher because the maximum working pressure of the high pressure unit exceeds 3.3 MPa. Particularly for vessels and piping and the like, instead of manufacturing and fabricating a raw material having an optimal wall thickness computed from the maximum working pressure of the high pressure unit, a raw material of the thick wall that satisfies the maximum working pressure condition is normally selected and fabricated from among standard products, such as JIS standard products. Consequently, by using a refrigerant

having saturation pressure characteristics higher than R407C, the wall thickness unfortunately increases substantially, and the cost of the parts constituting the refrigerant circuit unfortunately increase unnecessarily.

To prevent such an unnecessary cost increase in the air conditioner according to the present invention, a pseudo azeotropic refrigerant, an azeotropic refrigerant, or a single refrigerant is used as the refrigerant having saturation pressure characteristics higher than R407C, and an accumulator, capable of pooling the surplus refrigerant, which increases and decreases due to the fluctuations of the operating load of the plurality of utilization units, is installed in the low pressure unit having a maximum working pressure of less than 3.3 MPa; consequently, a receiver is no longer needed in the high pressure unit, and parts, such as the bypass pipe for preventing a compositional change in the refrigerant such as the case wherein a non-azeotropic refrigerant is used, are no longer necessary.

Thereby, by using a refrigerant having saturation pressure characteristics higher than R407C, it is possible to prevent an increase in the cost of the parts that constitute the refrigerant circuit, even if the maximum working pressure of the refrigerant circuit increases.

The air conditioner according to the second invention comprises a compressor, a heat source side heat exchanger, expansion mechanisms, a plurality of utilization side heat exchangers, a switching mechanism, and an accumulator. The compressor compresses low-pressure gas refrigerant and discharges high-pressure gas refrigerant. The heat source side heat exchanger is capable of functioning as an evaporator or a condenser. The plurality of utilization side heat exchangers are mutually connected in parallel, and each is capable of functioning as a condenser or an evaporator. The expansion mechanisms are connected between the utilization side heat exchangers and the heat source side heat exchanger. The switching mechanism is capable of switching between a state wherein the gas side of the heat source side heat exchanger is connected to the discharge side of the compressor, the inlet side of the compressor is connected

to the gas side of the utilization side heat exchangers, and low-pressure gas refrigerant is sucked into the compressor, and a state wherein the gas side of the heat source side heat exchanger is connected to the inlet side of the compressor, the discharge side of the compressor is connected to the gas side of the utilization side heat exchangers, and high-pressure gas refrigerant flows to the utilization side heat exchangers. The accumulator is connected between the switching mechanism and the inlet side of the compressor, and is capable of pooling low-pressure refrigerant as a liquid refrigerant. The low pressure unit, which includes the accumulator and is constituted by the connection of the switching mechanism and the inlet side of the compressor, can flow only low-pressure refrigerant at a maximum working pressure of less than 3.3 MPa. The high pressure unit, which is a part that excludes the low pressure unit and is constituted by the connection of the compressor, the heat source side heat exchanger, the plurality of utilization side heat exchangers, and the switching mechanism, can flow high-pressure refrigerant at a maximum working pressure of 3.3 MPa or higher. Further, the refrigerant that flows through the low pressure unit and the high pressure unit is a pseudo azeotropic refrigerant, an azeotropic refrigerant, or a single refrigerant having saturation pressure characteristics higher than R407C.

If using R407C as the working refrigerant of the air conditioner, then the standard working pressure of the high pressure unit is approximately 2.0 MPa. Consequently, if R407C is used as the working refrigerant, then it is often the case in an air conditioner that the maximum working pressure of the high pressure unit is set to 3.0 - 3.3 MPa, which is a pressure approximately 1 MPa higher than the standard working pressure of 2.0 MPa. Consequently, in the air conditioner that uses R407C as the working refrigerant, it is preferable that the parts constituting the high pressure unit have a compressive strength that can withstand 3.3 MPa.

However, if using a refrigerant having saturation pressure characteristics higher than R407C, then the parts constituting the high pressure unit must have a compressive strength that can withstand a pressure of 3.3 MPa or higher because the maximum working pressure of the

high pressure unit exceeds 3.3 MPa. Particularly for vessels and piping and the like, instead of manufacturing and fabricating a raw material having an optimal wall thickness computed from the maximum working pressure of the high pressure unit, a raw material of the thick wall that satisfies the maximum working pressure condition is normally selected and fabricated from among standard products, such as JIS standard products. Consequently, by using a refrigerant having saturation pressure characteristics higher than R407C, the wall thickness unfortunately increases substantially, and the cost of the parts constituting the refrigerant circuit unfortunately increases unnecessarily.

To prevent such an unnecessary cost increase in the air conditioner according to the present invention, a pseudo azeotropic refrigerant, an azeotropic refrigerant, or a single refrigerant is used as the refrigerant having saturation pressure characteristics higher than R407C, and an accumulator, capable of pooling the surplus refrigerant, which increases and decreases due to the fluctuations of the operating load of the plurality of utilization side heat exchangers, is installed in the low pressure unit having a maximum working pressure of less than 3.3 MPa; consequently, a receiver is no longer needed in the high pressure unit, and parts, such as the bypass pipe for preventing a compositional change in the refrigerant such as the case wherein a non-azeotropic refrigerant is used, are no longer necessary.

Thereby, by using a refrigerant having saturation pressure characteristics higher than R407C, it is possible to prevent an increase in the cost of the parts that constitute the refrigerant circuit, even if the maximum working pressure of the refrigerant circuit increases.

The air conditioner according to the third invention is the air conditioner according to the second invention, further comprising a heat source side temperature detector, utilization side temperature detectors, and a high pressure pressure detector. The heat source side temperature detector detects a refrigerant temperature on the liquid side of the heat source side heat exchanger. A utilization side temperature detector detects a refrigerant temperature on the liquid

side of each of the utilization side heat exchangers. The high pressure pressure detector detects a refrigerant pressure on the discharge side of the compressor. Furthermore, based on the values of the refrigerant temperature and the refrigerant pressure detected by the heat source side temperature detector, the utilization side temperature detectors, and the high pressure pressure detector, the opening of the expansion mechanism is regulated so that the liquid refrigerant on the liquid side of the heat source side heat exchanger reaches a prescribed subcooled state when the heat source side heat exchanger functions as a condenser, and the opening of each expansion mechanism is regulated so that the liquid refrigerant on the liquid side of the each utilization side heat exchanger reaches a prescribed subcooled state when the utilization side heat exchanger functions as the condenser.

In the present air conditioner, the surplus refrigerant, which increases and decreases according to the operating load, can be reliably pooled in the accumulator by setting the condensed refrigerant to a prescribed subcooled state when the heat source side heat exchanger functions as the condenser during cooling operation. In addition, the surplus refrigerant, which increases and decreases according to the operating load, can be reliably pooled in the accumulator by setting the condensed refrigerant to a prescribed subcooled state, even when the utilization side heat exchanger functions as the condenser during heating operation.

The air conditioner to the fourth invention is the air conditioner as recited in any one invention of the first invention through the third invention, wherein the refrigerant that flows through the low pressure unit and the high pressure unit includes R32.

In the present air conditioner, the air conditioning capacity can be improved because a refrigerant is used that includes R32, which has a high heat transport performance.

The air conditioner to the fifth invention is the air conditioner as recited in any one invention of the first invention through the third invention, wherein the refrigerant that flows through the low pressure unit and the high pressure unit is R410A.

In the present air conditioner, the air conditioning capacity can be improved more than when using R407C because R410A is used.

Brief Description of the Drawings

FIG. 1 is a schematic view of the refrigerant circuit of the air conditioner of one embodiment according to the present invention.

FIG. 2 is a Mollier diagram that depicts the refrigerating cycle of the air conditioner.

FIG. 3 is a chart that depicts the relationship between the working pressure and the wall thickness.

Preferred Embodiments of the Invention

The following explains an embodiment of the air conditioner according to the present invention, referencing the drawings.

(1) OVERALL CONSTITUTION OF THE AIR CONDITIONER

FIG. 1 is a schematic view of the refrigerant circuit of an air conditioner 1 according to one embodiment of the present invention.

The air conditioner 1 is, for example, an apparatus used in the cooling and heating of a building and the like, and comprises a heat source unit 2, a plurality of utilization units 5 (two units in the present embodiment) connected in parallel thereto, and a liquid refrigerant connecting pipe 6 and a gas refrigerant connecting pipe 7 for connecting the heat source unit 2 and the utilization units 5.

In the present embodiment, the air conditioner 1 uses R410A (50 wt% of R32 and 50 wt% of R125), which is a pseudo azeotropic refrigerant having saturation pressure characteristics higher than R407C, as the working refrigerant. R410A includes more R32, which has high heat transport performance, than does R407C, which improves the air conditioning capacity of the air conditioner 1.

(2) CONSTITUTION OF THE UTILIZATION UNIT

Each utilization unit 5 principally comprises a utilization side expansion valve 51, a utilization side heat exchanger 52, and a pipe connecting them.

In the present embodiment, the utilization side expansion valve 51 is an electric expansion valve connected on the liquid side of the utilization side heat exchanger 52 in order to regulate the refrigerant pressure, regulate the refrigerant flow, and the like.

In the present embodiment, the utilization side heat exchanger 52 is a heat exchanger that functions as a refrigerant evaporator during cooling operation to cool the indoor air, and functions as a refrigerant condenser during heating operation to heat the indoor air. In addition, the utilization side heat exchanger 52 is provided with a utilization side temperature detector 53 that detects the refrigerant temperature. In the present embodiment, the utilization side temperature detector 53 is a thermistor disposed on the liquid side of the utilization side heat exchanger 52.

(3) CONSTITUTION OF THE HEAT SOURCE UNIT

The heat source unit 2 principally comprises a compressor 21, a four-way switching valve 22, a heat source side heat exchanger 23, a heat source side expansion valve 24, an accumulator 25, a liquid side gate valve 26, a gas side gate valve 27, and pipes that connect them.

In the present embodiment, the compressor 21 is a variable capacity compressor that compresses low-pressure gas refrigerant and discharges high-pressure gas refrigerant. In addition, a high pressure pressure detector 28 comprising a pressure sensor that detects the pressure of the high-pressure gas refrigerant is provided on the discharge side of the compressor 21.

The four-way switching valve 22 is a valve that switches the direction of the flow of the refrigerant when switching between cooling operation and heating operation; during cooling operation, the discharge side of the compressor 21 and the gas side of the heat source side heat exchanger 23 can be connected, and the inlet side of the compressor 21 (specifically, the accumulator 25) and the gas refrigerant connecting pipe 7 side can be connected (refer to the

solid line of the four-way switching valve 22 in FIG. 1); and during heating operation, the discharge side of the compressor 21 and the gas refrigerant connecting pipe 7 side can be connected, and the inlet side of the compressor 21 and the gas side of the heat source side heat exchanger 23 can be connected (refer to the broken line of the four-way switching valve 22 in FIG. 1).

In the present embodiment, the heat source side heat exchanger 23 is a heat exchanger that functions as a refrigerant condenser during cooling operation with the outdoor air or water as the heat source, and functions as a refrigerant evaporator during heating operation with the outdoor air or water as the heat source. In addition, the heat source side heat exchanger 23 is provided with a heat source side temperature detector 29 that detects the refrigerant temperature. In the present embodiment, the heat source side temperature detector 29 is a thermistor disposed on the liquid side of the heat source side heat exchanger 23.

The heat source side expansion valve 24 is connected on the liquid side of the heat source side heat exchanger 23 and, in the present embodiment, is an electric expansion valve for regulating the refrigerant flow between the heat source side heat exchanger 23 and the utilization side heat exchanger 52, and the like.

The accumulator 25 is connected between the four-way switching valve 22 and the compressor 21, and is a vessel for pooling the low-pressure refrigerant and the surplus refrigerant sucked into the compressor 21.

The liquid side gate valve 26 and the gas side gate valve 27 are respectively connected to the liquid refrigerant connecting pipe 6 and the gas refrigerant connecting pipe 7. The liquid refrigerant connecting pipe 6 is connected between the liquid side of the utilization side heat exchanger 52 of each utilization unit 5 and the liquid side of the heat source side heat exchanger 23 of the heat source unit 2. The gas refrigerant connecting pipe 7 is connected between the gas

side of the utilization side heat exchanger 52 of each utilization unit 5 and the four-way switching valve 22 of the heat source unit 2.

The refrigerant circuit wherein are successively connected the utilization side expansion valves 51, the utilization side heat exchangers 52, the compressor 21, the four-way switching valve 22, the heat source side heat exchanger 23, the heat source side expansion valve 24, the accumulator 25, the liquid side gate valve 26, and the gas side gate valve 27, as explained above, constitutes a refrigerant circuit 10 of the air conditioner 1.

(4) OPERATION OF THE AIR CONDITIONER

The following explains the operation of the air conditioner 1 under standard working conditions, referencing FIG. 1 and FIG. 2. Herein, FIG. 2 is a Mollier diagram that depicts the refrigerating cycle of the air conditioner 1.

<DURING COOLING OPERATION>

During cooling operation, the four-way switching valve 22 is in the state depicted by the solid line in FIG. 1, i.e., the discharge side of the compressor 21 and the gas side of the heat source side heat exchanger 23 are connected, and the inlet side of the compressor 21 and the gas side of the utilization side heat exchangers 52 are connected. In addition, the liquid side gate valve 26 and the gas side gate valve 27 are opened, and the utilization side expansion valves 51 are fully opened. The heat source side expansion valve 24 is in a state wherein the opening can be regulated by the subcooling control based on the high pressure pressure detector 28 and the heat source side temperature detector 29. More specifically, a degree of subcooling of the high-pressure liquid refrigerant is calculated based on the temperature differential between a saturation temperature corresponding to a pressure value of the high-pressure gas refrigerant detected by the high pressure pressure detector 28 and a temperature value of the high-pressure liquid refrigerant detected by the heat source side temperature detector 29, and the opening of the

heat source side expansion valve 24 can be regulated so that the degree of subcooling reaches a prescribed value.

If the compressor 21 activates in this state of the refrigerant circuit 10, then the low-pressure gas refrigerant (pressure Ps = approximately 0.9 MPa, and temperature Ts = approximately 15° C) is sucked into and compressed by the compressor 21 to form the high-pressure gas refrigerant (pressure Pd = approximately 3.0 MPa, and temperature Td = approximately 70° C) (refer to the point A and the point B in FIG. 2). Subsequently, the high-pressure gas refrigerant is sent to the heat source side heat exchanger 23 via the four-way switching valve 22, is heat exchanged with the outdoor air or water that forms the heat source, is condensed, and is cooled to a temperature Tc (approximately 45° C) slightly lower than the saturation temperature Tsat (approximately 50° C) at pressure Pd (refer to the point C in FIG. 2). Herein, the high pressure liquid refrigerant subcooling temperature ΔTc in the point C state (i.e., Tsat - Tc) is maintained at a constant level (herein, ΔTc = approximately 5° C) by the subcooling control based on the heat source side expansion valve 24.

Furthermore, the pressure of this condensed liquid refrigerant is reduced in accordance with the opening of the heat source side expansion valve 24, becomes a low-pressure vapor-liquid two-phase refrigerant (pressure Ps = approximately 0.9 MPa, temperature TD = approximately 3° C) (refer to point D in FIG. 2), and is sent to each utilization unit 5 via the liquid side gate valve 26 and the liquid refrigerant connecting pipe 6.

After the vapor-liquid two-phase refrigerant sent to each utilization unit 5 passes through the utilization side expansion valve 51, its heat is exchanged with the indoor air by the utilization side heat exchanger 52, it evaporates, and then once again becomes a low-pressure gas refrigerant (pressure Ps = approximately 0.9 MPa, temperature Ts = approximately 15° C) (refer to point A in FIG. 2). This low-pressure gas refrigerant passes through the gas refrigerant connecting pipe 7, the gas side gate valve 27, and the four-way switching valve 22, and flows

into the accumulator 25. Furthermore, the low-pressure gas refrigerant that flowed into the accumulator 25 once again is sucked into the compressor 21.

Furthermore, as explained above, because the high pressure liquid refrigerant subcooling temperature ΔTc is maintained at a constant level in the point C state by the subcooling control based on the heat source side expansion valve 24, the state change is maintained as in the refrigerating cycle depicted in FIG. 2 and the surplus refrigerant pools in the accumulator 25, even if the operating load of each utilization unit 5 fluctuates, changing the amount of refrigerant circulating.

In addition, if low-pressure liquid refrigerant flows from the utilization side heat exchanger 52 along with the low-pressure gas refrigerant into the accumulator 25, or if the surplus refrigerant pools in the accumulator 25, then the low-pressure gas refrigerant and liquid refrigerant inside the accumulator 25 undergo vapor-liquid separation, and only the low-pressure gas refrigerant is sucked into the compressor 21. At this time, because R410A, which is one of the pseudo azeotropic refrigerants, is used as the working refrigerant in the present embodiment, the refrigerant composition of the low-pressure gas refrigerant sucked into the compressor 21 and the refrigerant composition of the liquid refrigerant that pooled in the accumulator 25 are maintained at a constant level by the vapor-liquid separation inside the accumulator 25.

<DURING HEATING OPERATION>

During heating operation, the four-way switching valve 22 is in the state indicated by the broken line in FIG. 1, i.e., the discharge side of the compressor 21 is connected to the gas side of the utilization side heat exchangers 52, and the inlet side of the compressor 21 is connected to the gas side of the heat source side heat exchanger 23. In addition, the liquid side gate valve 26 and the gas side gate valve 27 are opened, and the heat source side expansion valve 24 is in a full-open state. Each utilization side expansion valve 51 is in a state wherein the valve opening can be regulated by the subcooling control based on the high pressure pressure detector 28 and the

respective utilization side temperature detector 53. More specifically, the degree of subcooling of the high-pressure liquid refrigerant is calculated based on the temperature differential between the saturation temperature corresponding to the pressure value of the high-pressure gas refrigerant detected by the high pressure pressure detector 28 and the temperature value of the high-pressure liquid refrigerant detected by the respective utilization side temperature detector 53, and the opening of the respective utilization side expansion valve 51 can be regulated so that the degree of subcooling reaches a prescribed value.

If the compressor 21 is activated in this refrigerant circuit 10 state, the low-pressure gas refrigerant is sucked into and compressed by the compressor 21, becomes a high-pressure gas refrigerant, and is then sent to the each utilization unit 5 via the four-way switching valve 22, the gas side gate valve 27, and the gas refrigerant connecting pipe 7. Furthermore, the high-pressure gas refrigerant sent to each utilization unit 5 is heat exchanged with the indoor air and condensed in the utilization side heat exchanger 52, and is cooled to a temperature slightly lower than the saturation temperature of the high-pressure gas refrigerant. Herein, the degree of subcooling of the high-pressure liquid refrigerant in the point C state is maintained at a constant level by the subcooling control based on the respective utilization side expansion valve 51. The pressure of this condensed liquid refrigerant is reduced in accordance with the opening of the respective utilization side expansion valve 51, becomes a low-pressure vapor-liquid two-phase refrigerant, and is sent to the heat source unit 2 via the liquid refrigerant connecting pipe 6 and the liquid side gate valve 26. Furthermore, after the vapor-liquid two-phase refrigerant sent to the heat source unit 2 passes through the heat source side expansion valve 24, its heat is exchanged with the outdoor air or water, which forms the heat source, by the heat source side heat exchanger 23, is then evaporated, once again becomes a low-pressure gas refrigerant, and flows into the accumulator 25 via the four-way switching valve 22. Furthermore, the low-pressure gas refrigerant that flowed into the accumulator 25 once again is sucked into the compressor 21.

Thus, the refrigerant flows during heating operation in a direction the opposite of the flow during cooling operation; in addition, although there is a point of difference in that subcooling control is performed by the utilization side expansion valve 51, the refrigerant state change is the same as the refrigerating cycle state change as shown in FIG. 2.

(5) DESIGN PRESSURE OF PARTS CONSTITUTING THE REFRIGERANT CIRCUIT

As can be understood from the above explanation of the operation of the air conditioner 1 during cooling operation and during heating operation, the refrigerant circuit 10 comprises a high pressure unit 10a, which is a refrigerant circuit part wherein high-pressure refrigerant flows, and a low pressure unit 10b, which is a refrigerant circuit part wherein only low-pressure refrigerant flows. Specifically, the low pressure unit 10b is a part that includes the accumulator 25 and wherein the four-way switching valve 22 and the inlet side of the compressor 21 are connected; and the high pressure unit 10a is the part of the refrigerant circuit 10 that does not include the low pressure unit 10b.

Herein, the parts that constitute the high pressure unit 10a (specifically, the compressor 21, the four-way switching valve 22, the heat source side heat exchanger 23, the heat source side expansion valve 24, the liquid side gate valve 26, the gas side gate valve 27, the utilization side expansion valves 51, and the utilization side heat exchangers 52) and the piping are designed taking into consideration a margin of approximately 1 MPa with respect to the standard working pressure (approximately 3.0 MPa) of the abovementioned high-pressure refrigerant so that high-pressure refrigerant can flow at the maximum working pressure (approximately 4 MPa). In addition, the parts that constitute the low pressure unit 10b (specifically, the accumulator 25) and the piping are designed taking into consideration a margin of approximately 1 MPa with respect to the standard working pressure (approximately 0.9 MPa) of the abovementioned low-pressure refrigerant, so that low-pressure refrigerant can flow at the maximum working pressure (approximately 2 MPa).

(6) FEATURES OF THE AIR CONDITIONER

The air conditioner 1 of the present embodiment has the following features.

(A)

It is unnecessary in the air conditioner 1 of the present embodiment to provide the high pressure unit 10a with a receiver because: R410A is used as the refrigerant having saturation pressure characteristics higher than R407C; and an accumulator 25, capable of pooling surplus refrigerant that increases and decreases due to fluctuations in the operating load of the plurality of utilization units 5, is installed in the low pressure unit 10b, which has a maximum working pressure of less than 3.3 MPa.

Thereby, the use of a refrigerant in the air conditioner 1 having saturation pressure characteristics higher than R407C can prevent cost increases in the parts constituting the refrigerant circuit, even if the maximum working pressure of the refrigerant circuit increases.

The effect of preventing a cost increase will be explained, for the case wherein the maximum working pressure of the refrigerant circuit increases due to the use of R410A as the working refrigerant, by comparing the case wherein the accumulator 25 is provided in the low pressure unit 10b as in the present embodiment with the case wherein the high pressure unit 10a is provided with a receiver (not shown) as in the conventional case.

For example, if fabrication and manufacture are performed using the JIS standard STPG 370E (carbon steel pipes for pressure service) as the raw material for the accumulator 25, which is cylindrically shaped and has a nominal diameter of ten inches, and the receiver, then it is conceivable to select schedule 20 (thickness 6.4 mm) or schedule 30 (thickness 7.8 mm). Further, as shown by the chart in FIG. 3 depicting the relationship between the working pressure and the wall thickness, schedule 20 raw material can be used up to a working pressure of 3.3 MPa, and schedule 30 raw material can be used up to 4.3 MPa.

Herein, because the maximum working pressure of the accumulator 25 is approximately 2.0 MPa (the maximum working pressure of the low pressure unit 10b), even schedule 20 raw material can be selected because it has sufficient compressive strength. However, because the maximum working pressure of the receiver is approximately 4.0 MPa (the maximum working pressure of the high pressure unit 10a), schedule 20 raw material cannot be used; moreover, schedule 30 raw material must be selected regardless of the fact that the approximately 7.4 mm wall thickness is sufficient based on calculations.

Thus, because the maximum working pressure of the high pressure unit is 3.0 - 3.3 MPa if R407C is used as the working refrigerant of the air conditioner, it is possible to use schedule 20 raw material; however, in a case wherein a refrigerant is used, as in the present embodiment, having saturation pressure characteristics higher than R407C, such as R410A, the use of the receiver as the vessel that pools the surplus refrigerant results in a substantial increase in wall thickness, which unfortunately increases the cost of the parts that constitute the refrigerant circuit unnecessarily. In other words, as above mentioned, in the case wherein a refrigerant is used, such as R410A, having saturation pressure characteristics higher than R407C, then an increase in the cost is prevented more if the accumulator is used instead of the receiver as the vessel that pools the surplus refrigerant.

(B)

In addition, because R410A is a pseudo azeotropic refrigerant, parts such as the bypass pipe are no longer necessary to prevent compositional changes in the refrigerant, such as in the case wherein a non-azeotropic refrigerant like R407C is used, even if using the accumulator 25 as the vessel that pools the surplus refrigerant, and it is therefore possible to prevent an increase in the cost of the parts that constitute the refrigerant circuit.

(C)

Furthermore, the degree of subcooling based on the high-pressure liquid refrigerant is calculated during cooling operation in the air conditioner 1 based on the temperature differential between the pressure value of the high-pressure gas refrigerant detected by the high pressure pressure detector 28 and the temperature value of the high-pressure liquid refrigerant detected by the heat source side temperature detector 29, and the opening of the heat source side expansion valve 24 can be regulated so that the degree of subcooling reaches a prescribed value; consequently, the surplus refrigerant, which increases and decreases according to the operating load, can be reliably pooled in the accumulator 25. In addition, the degree of subcooling based on the high-pressure liquid refrigerant during heating operation is calculated based on the temperature differential between the pressure value of the high-pressure gas refrigerant detected by the high pressure pressure detector 28 and the temperature value of the high-pressure liquid refrigerant detected by the utilization side temperature detector 53, and the opening of the utilization side expansion valve 51 can be regulated so that the degree of subcooling reaches a prescribed value; consequently, the surplus refrigerant, which increases and decreases according to the operating load, can be reliably pooled in the accumulator 25.

(7) OTHER EMBODIMENTS

The above explained an embodiment of the present invention based on the drawings, but the specific constitution is not limited to these embodiments, and it is understood that variations and modifications may be effected without departing from the spirit and scope of the invention.

(A)

The air conditioner of the abovementioned embodiment uses a refrigerant circuit capable of cooling and heating operation; however, the present invention is not limited thereto, and may be applied to an air conditioner having a refrigerant circuit dedicated for cooling or for heating that does not use a 4-way switching valve.

(B)

In the abovementioned embodiment, R410A, which is one type of pseudo azeotropic refrigerant, was used as the working refrigerant; however, the present invention is not limited thereto, and it is also acceptable to use a pseudo azeotropic refrigerant having a R32:R125 compositional ratio different than that of R410A, such as R410B (R32: 45 wt%, R125: 55 wt%), a single refrigerant like R32, and other pseudo azeotropic refrigerants or azeotropic refrigerants.

Applicability of Industry

The use of the present invention enables, in an air conditioner comprising a plurality of utilization units, the prevention of a cost increase in the parts constituting the refrigerant circuit, even if the maximum working pressure of the refrigerant circuit increases, by the use of a refrigerant having saturation pressure characteristics higher than R407C.